General Application Name: County Executive & Board of Supervisors

Product / Service / Function Name: Land Use & Development Studies

P/S/F Description:

Land use and development studies are intended to provide a snapshot in time for the purpose of providing information to planners about how land is being utilized. Most often, land use categories are mapped and acreage calculations are derived to give planners tangible data. Knowing how land is being used and what the patterns of use are in a county or city greatly assist decision makers in planning for the future. Land use studies can also be done for environmental studies, but these are less dependent on the need to compare and assess ownership or potential development opportunities, as is the case with a traditional land use study. Depending on the type of land use study undertaken, more or less weight is given to the "use" of the land versus the "land cover" when determining the land use classification that should be assigned to a particular area.

With sophisticated GIS capabilities, maintaining multiple layers containing contiguous line features (e.g. parcel boundaries and land use boundaries) of multiple data layers over time is made easier. For instance, as new subdivisions are developed, new land use divisions can be added to the land use layer to reflect the change in land use or land cover while maintaining the integrity of the data set for accurate acreage calculations and mapping.

Product / Service / Function

1. Spatial Data

Minimum Data Requirements

General Description	GIS Data Layer
Planimetrics/Land Base	Parcels
	Orthophotography
Transportation	Road centerlines
	Right-of-way and/or edge of pavement
Natural Features	Digital Elevation Model
	National Wetland Inventory
	FEMA Floodplains
	Streams
	Lakes
Socio-Political Data	Land Use
	Municipal boundaries
	Neighborhoods & Subdivisions
	Zoning

Optional Data Requirements

General Description	GIS Data Layer
Natural Features	Vegetation
Transportation	Railroads
	Driveways

	Parking Lots
	Gas
	Electric
	Storm water
Socio-Political Data	Census Block/Tract
	School Zone
	Agricultural Security Areas
Utilities Data	Water Lines
	Sewer Lines
Other	Satellite Imagery

2. Attribute Data

Minimum Attribute Requirements

GIS Data Layer	Attributes
Land Use	LU (Land Use) Code
	LU Description
	Symbol
	District
	Zoning
	Parcel Identification Number
	Acres
	Neighborhood
	Development Potential
	Future LU Code
	Future LU Description
Streets	Street Name

Optional Attribute Requirements

GIS Data Layer	Attributes
Land Use	Slope
	Transportation
	Lot Dimensions
	Subdivision/Neighborhood
	Utilities (connected/not connected)
	Residence Type

3. Data Acquisition Options

Land use information itself is derived from a combination of sources. The main source is via interpretation of orthophotographs. The technician visually identifies the different land use patterns on the ortho and then digitizes the polygon features on top of the orthophoto. However, it is also critical to have parcels and zoning information as well to aid in the land use identification process. Manual interpretation is the best method to obtain current land use patterns.

The USGS maintains Land Use/Land Cover (LULC) data in a GIS format and is available free of charge <http://edc.usgs.gov/products/landcover/lulc.html>. This data is based on interpretation of aerial photos from the 1970's and 1980's, with maps and surveys as supplemental sources. The LULC data is available at the 1:100,000 and 1:250,000 scale and utilizes the industry standard 21-category land use classification system. If the city/county does not have historical land use mapping, then this information would be useful to add to its data warehouse.

Planimetric data such as parcels, utilities, buildings, streets, etc. are typically maintained at the county or city level. Street centerline data layers of varying qualities can be obtained from a number of vendors. The market is relatively competitive, and prices will vary with quality of the data. Relevant vendors that provide this kind of spatial data on a regional and national scale include: NAVTECH <www.navtech.com>, GDT <www.geographic.com>, and TeleAtlas <www.teleatlas.com>.

Other spatial data layers can be obtained through the Internet from various government sources. Municipal boundaries and similar layers can be obtained in digital format through the U.S. Census Bureau <www.census.gov>. Floodplains can be obtained through the FEMA Web site <www.fema.com>.

4. Data Conflation Options

Data conflation is a process by which two digital data layers, usually of the same area at different points in time, or two different data layers of the same area, are geographically "corrected" through geometrical and rotational transformations so that the different layers can be overlaid on one another. Also called "rubber-sheeting," this process allows a technician to adjust the coordinates of all features on a data layer to provide a more accurate match between known locations and a few data points within the base data set. A good base layer to use for data conflation is the VBMP orthophotos since many features can be seen or interpreted. The need and processes for conflation varies between sets of data, users, and feature types. Any dataset that is updated independently by different departments can be consolidated through conflation. Within most local governments, individual departments are responsible for maintaining specific datasets within their expertise; therefore, conflation is not often necessary. Often, reprojecting the data into a different coordinate system will take care of the misalignment of different data sets. Most industry-standard GIS software has the ability to perform data conflation.

If the LULC data is obtained from the USGS, then it would need to be projected from UTM to the Virginia State Plane coordinate system, which is the coordinate system of the VBMP orthophotos. Any other data from Federal or local sources such as wetlands, census data, parcels and centerlines must also be reprojected to the Virginia State Plane system.

5. GUI / Programming Options

There a few options for developers of a GIS-based land use analysis application. Two avenues within this development track are:

- Off-the-shelf GIS desktop application that can be customized to the user's needs
- Hiring a consultant to develop a custom system from scratch.

Using a standard GIS software package often requires a significant amount of training and customization. Whereas the initial cost may be lower, the time invested in learning these solutions

may generally increase the overall expense of implementation. However, standard GIS software packages deliver more robust data integration, analysis, and cartographic capabilities than do other specialized commercial applications. They have a greater user support infrastructure that allows users to overcome problems quickly. Options for using an existing, industry-standard GIS software application that can be customized for land use and development studies include those listed in the following table:

Standard GIS Software Vendors:

Vendor	Software	Web Address
ESRI	ArcView 3.x	http://www.esri.com
ESRI	ArcGIS 8.x	http://www.esri.com
MapInfo	Professional 7.0	http://www.mapinfo.com
Intergraph	GeoMedia 5.0	http://www.intergraph.com/gis
Autodesk	Map 5.0	http://www.autodesk.com

The second option is to contract with a consultant to develop and implement a tailored GIS-based land use and development application. This option makes certain that a product will fulfill a jurisdiction's requirements. A consultant will be able to develop an application that works with the wide range of hardware and software that are currently in use within local governments within Virginia. Also, training and follow-up user support is often provided at a much more substantial level than with other options.

There are a number of functions that a GIS application could perform for land use analysis. A GIS has the ability to analyze locational information and the relationships between projects of different types in a given geographic area. For example, it is possible to consider the existing transportation infrastructure with current and future land use areas, the terrain, flood prone areas, wetlands, and other existing features and determine the best place to site a new transportation corridor. The GIS allows users' to speculate by changing layers or parameters and to print maps of the various scenarios. Land use data is also influential in the creation of a master plan. This type of application could be very powerful and would greatly assist a county or municipality in justifying their decisions.

6. Internet Functionality and options

The Internet has proven itself as a viable solution for local governments to centralize the maintenance and management of services and data. As more local governments are implementing Web-based solutions, they are finding that the Internet requires them to change the nature of an application or its usefulness. Through the flexibility of an Internet solution, software can be easily updated, and users gain greater accessibility to the applications and information they need for their specific tasks through simple, user-friendly interfaces.

A municipality may choose to add an land use or land cover data layer along with other data layers to an interactive mapping site or display maps of proposed land use changes for the public's information. Another option is to display a map showing changes in land use over time overlaid on the VBMP orthophotos. GIS software vendors have products that can be customized in-house or by a consultant to provide Web GIS applications on the Internet, over an intranet or via wireless network. The table below shows GIS vendors and their Internet mapping solutions.

GIS Internet Solutions

Vendor	Internet Software	Web Address
ESRI	ArcIMS	http://www.esri.com/software/arcims
MapInfo	MapXtreme, MapX	http://www.mapinfo.com
Intergraph	GeoMedia WebMap	http://www.intergraph.com/gis/gmwm
Autodesk	MapGuide	http://www.autodesk.com

7. Technical Requirements

Minimum Technical Requirements
At its most basic level, a GIS-based land use analysis application can be used on a single, stand-alone workstation. A typical workstation running off-the-shelf software should have the following minimum specifications:

Processor: Pentium 3; 450 MHz
RAM: 128MB SDRAM at 133MHz
Hard Disk: 20GB (min.)
Monitor 1:   19"
Floppy Drive: 3.5"
CD-ROM: 12x/8x/32x CD drive
Modem: 56K
OS: Windows 2000/NT/XP
Office: Windows 2000 Professional
Printer: 8x11 office-grade color printer

Optimum Technical Requirements:
A more complex application may require multiple components, including servers, desktop workstations, or handheld devices. For either a desktop or a Web-based application, the system should rely on a fairly robust server computer and high-end workstations. Example specifications of the necessary equipment are listed below:

Server
Processor: Min. 2 Processors, 1.7 GHz, 512K cache
RAM: Min. 2x 512MB RIMMS
Hard Disk: Min. 2x 80GB +RAID
Monitor 1:   19"
Floppy Drive: 3.5"
CD-ROM: 12x/8x/32x CD drive
Modem: 56K
Network Card: 10/100 mbps

Workstation
Processor: Pentium 4, 1.5 GHz
RAM: 512MB SDRAM at 133MHz
Hard Disk: 20GB (min.)
Monitor 1:   19"
Monitor 2:   17"
Floppy Drive: 3.5"

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CD-ROM:        12x/8x/32x CD-RW drive
Modem:         56K
Network Card:  10/100 mbps
OS:            Windows 2000/NT/XP
Office:        Windows 2000 Professional
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Other Components
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Printer:       8x11 office-grade color printer and 8x11 production b/w printer
Plotter:       HP DesignJet 1055CM
Tape Backup:   Tape Library Server
UPS:           APC 1400 (or other similar)
Scanner:       11x17
Handheld:      Compaq IPAQ
Network:       T1
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8. Administrative/Management Requirements

At the beginning of the project, the assigned committee member from the particular county should consider completing some, if not all of the following tasks that relate to the administrative requirements of a land use analysis application:

- Determine, with or without the assistance of a consultant hired to develop the system, the preliminary vision and goals of the project.
- Coordinate an initial meeting with the stakeholders (e.g. Board of Supervisors, City Council, planning department, real estate division, environmental agencies, etc.) where the vision and goals of the project are expressed and the background of GIS technology is described, if needed.
- Coordinate with other municipal agencies for data sharing provisions.
- Determine a mechanism of communication to keep the decision-makers aware of the progress of the project.
- Develop a basic understanding of the available precedents in the region/state and research the available technologies that can be applied to the project.

Upon project completion, a basic GIS-based land use analysis application will require very little administrative support to run. Administrative tasks may include loading or upgrading new versions of the software or patches, providing for constant data flow, and maintaining yearly support contracts on the hardware and software. However, once the system becomes distributed as an enterprise solution to many users throughout a department or deployed on the Internet, there are various other management requirements that need to be fulfilled on a weekly or monthly basis.

At the point where the system grows beyond single desktop users, a devoted administrator or system manager needs to be established. This is essential for the following reasons:

- The system will now be interfacing with other technology systems already in place. Therefore, someone needs to maintain contact with the technology personnel that maintain these systems.
- The manager needs to put into place training schedules to maintain user knowledge of the system.
- Funding will undoubtedly be required to either maintain the system long-term, or continue to expand the system, which requires funding research and applications for grants.

- A GIS-based land use analysis application will only succeed when it is maintained on a predetermined schedule with rigorous analysis and planning.

9. Cost – Cost/Benefit

Hardware	Average Unit Cost
Minimum Workstation	$2,000
Optimum Workstation	$3,200
Laptop	$2,400
Web/FTP Server	$8,500
Database Server	$12,000
Data Warehouse Server	$18,000
Backup Server	$5,800
Printer (8x11 color)	$700
Printer (8x11 b/w production)	$2,000
Plotter	$12,000
Tape Library	$5,000
UPS (Universal Power Supply)	$700
Scanner	$1,500
Handheld	$300-$700

Software (all prices included license)	Typical Unit Cost
Standard GIS desktop software	$700-$10,000
Customized desktop vendor solution	$5,000-$15,000
Web-based vendor application	$15,000-$25,000
Customized web-based vendor solution	$20,000-$60,000

Miscellaneous	Typical Unit Cost
GPS consultant survey	$15,000-$90,000 (depends on size)
Training – general GIS	$700-$1,200
Licensing – desktop	$100-$500
Licensing – webapp (1st CPU)	$7,500-$12,000
Maintenance (per year)	$8,000-$15,000

10. Standards / Guidelines Summary
- Choose one of the industry-standard land use coding schemes to attribute the land use data layer (e.g. Anderson et al, 1976* or AICP classifications**) instead of the "land use" classification from the tax assessment codes, which is not as precise.
- Choose a minimum polygon size (smallest unit of space that will be identified) when interpreting land use from orthophotos. This usually ranges from .25 – 2 acres. This will depend on the quality and scale of the orthophotos.
- Consider creating, or purchasing an application that integrates land use analysis with other government information management tools
- A GIS-based land use analysis application should be built such that non-technical personnel can be trained to use the system.
- Acquire input from all departments who will be involved in funding and/or utilizing the application before proceeding with the application design.

- Develop a detailed Quality Assurance/Quality Control (QA/QC) procedure for reviewing the accuracy of the GIS data and its attributes.
- Maintain data in the VBMP standard coordinate system (Virginia State Plane, NAD 83, Survey Feet).
- Create metadata (standard information about GIS data) for each data layer. Metadata tracks the date, origin, coordinate system, and other such information for data layers.

* http://edc.usgs.gov/glis/hyper/guide/1_250_lulc
** http://www.planning.org/lbcs/

11. Startup Procedures/Steps

There should be a minimum of eight steps involved with developing a GIS-based land use analysis application, after funding is in place to support the project. The steps can be performed in-house or by a consulting team.

The first task is to complete a detailed Needs Assessment. This process gathers information regarding existing operational procedures, hardware and software, GIS data, and personnel needs. It should include interviews of key individuals throughout the local government agency and other related government departments to obtain a comprehensive view of the agency's operations, and where GIS might improve them. Basic GIS concepts should be discussed and illustrated to those interviewees that have little prior understanding of GIS. A comprehensive Needs Assessment should then be compiled from the results of the interviews. This document explains the various requirements for a GIS-based land use analysis application in the following areas: personnel needs, spatial data development needs, applicable spatial analysis techniques, basic system requirements, including preliminary, general hardware and software recommendations, and training needs.

The second task is to develop a functional requirements document for the proposed system. This document should describe, as completely as possible, all of the technology and functionality that is to be included in the land use and development analysis system. This document is used by the local government agency, or its consultant, as the blueprint for the GIS application or system. The following topics should be addressed:

- Hardware specifications
- Software purchases
- Detailed descriptions of work-flow, and examples of the graphic user interfaces
- Describe each tool that is part of that graphic user interface, and its functionality
- Describe how data would flow between the different databases and data warehouses, if applicable
- Describe the redundant security measures that will be put in place to make certain of data integrity and confidentiality, when applicable
- Techniques that the application/system provides the user for land use analysis
- Describe each of the potential products (reports, maps, charts, summary tables) that the user will be able to generate within the system

The third task should be to compile or develop spatial data that can be used by the evolving application. Data can be gathered from a number of online sources, as well as county/city departments. The data layers gathered and maintained should match at least the minimum list

provided in Section 1 of this document and can be acquired through the methods described in Section 3 of this document.

On completion and acceptance of the functional requirements document and the development of the spatial and attribute data, the system development and test phase can begin. During this time, the application will be customized as it was outlined in the functional requirements phase. The local government agency should require periodic reviews of the application at particular milestones, such as 50% and 75% completion. This will make certain that problems with the application will be recognized early in the development process, and that the local government agency remains a part of the development process throughout the project timeline.

When the application is nearing 100% completion, it should be installed and tested in the environment in which it will ultimately be used. This allows the users to test the system alongside the application developers, and determine any system integration problems that might arise. It also gives the developers the opportunity to test the application's functionality in a real-world situation. This testing process should be as comprehensive as possible. Each process detailed within the functional requirements should be tested and evaluated at this point.

User training commences once the application reaches completion and is fully documented. Different levels of tutorials and system documentation should be developed depending on the hierarchy of users. Time should be spent at this stage of the project with each potential user of the system to make certain that the proper education occurs. Training should be done through lessons that use real-life examples of system application. This strategy greatly enhances users' ability to apply the functionality to their jobs.

The next phase of the project should include a document that describes a future plan for wider system development. This document accomplishes two goals. The future plan gives the local government agency ideas on how the system might grow to assist other facets of its business practices. Secondly, it provides the agency with a ready-made grant proposal for applying for potential funding sources.

The final phase of a successful implementation of a GIS-based land use and development studies application is ongoing technical support. The local government agency should always include this contingency within its cost estimates of a project for a minimum of three months after a system has been put into place. No matter how effective an application appears, problems and system changes inevitably impact the functionality of an application.

12. Estimated time line and/or implementation (stand alone) schedule

Phase	Approximate Duration
RFP/Contract process (construction, posting, proposal acceptance, review, award of contract)	4 months - 1 year
Needs Assessment	2 months
Functional Requirements	1-2 months
Data Development	6-12 months
System Development and Testing	2-4 months
Installation and Testing	1 month
User Training	½ month
Plan for Future Development	½ month

Ongoing Support	3 months

13. Best Practice Examples in Virginia

Fairfax County, Virginia
Community Development Center
12055 Government Center Parkway
Fairfax, VA 22035
(703)-324-1380
http://www.co.fairfax.va.us/gov/ocp/homepage.htm